Quantitative interpretation flow

2015

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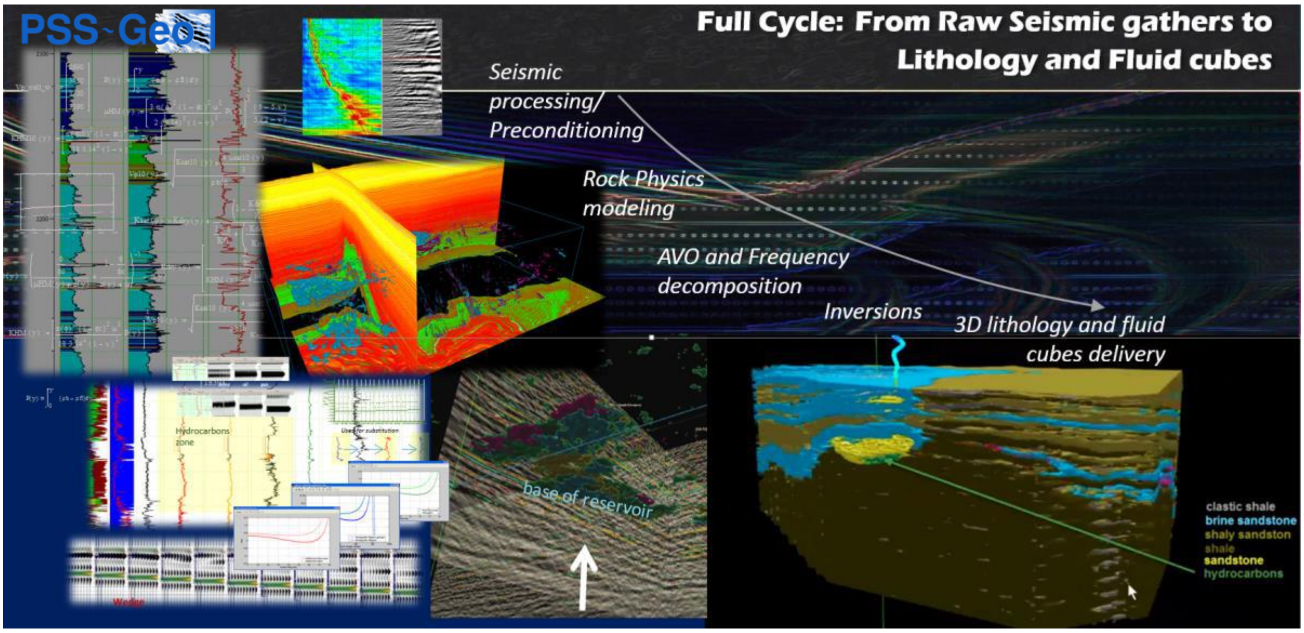

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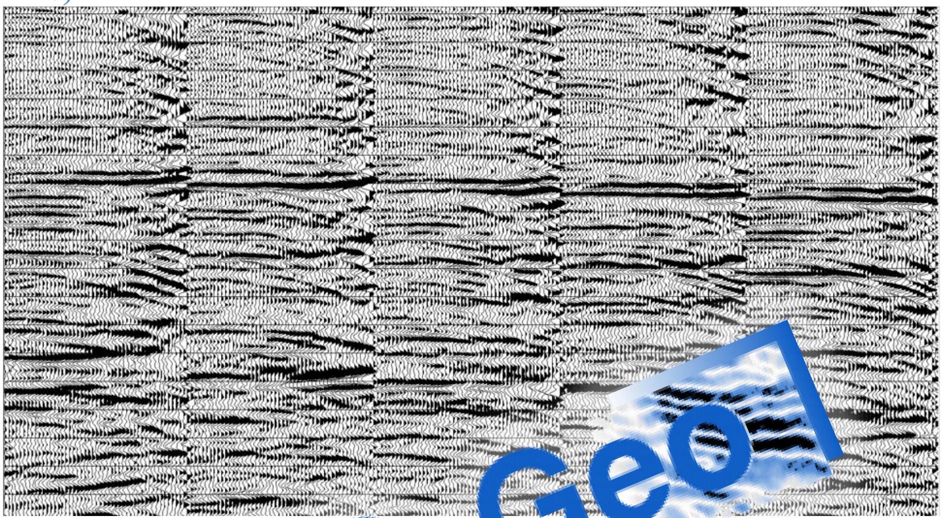
1) **Preconditioning**

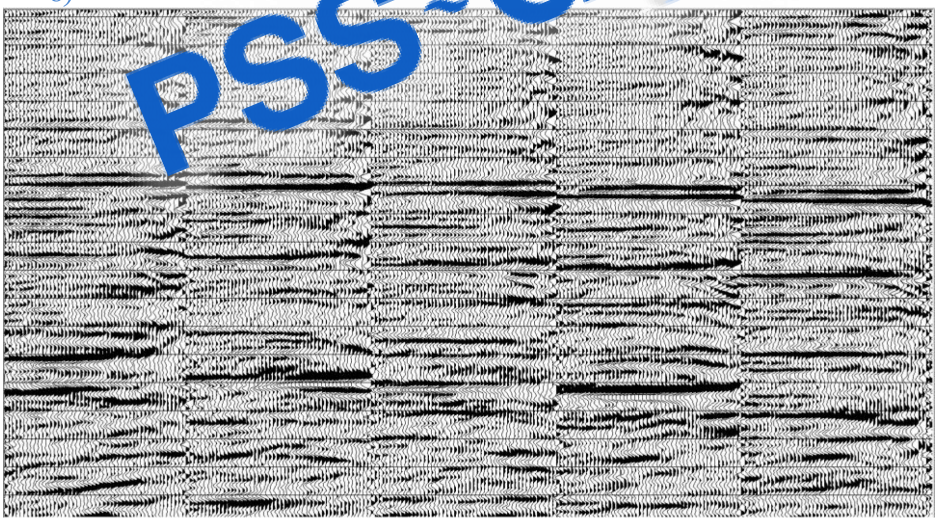
   a) Data delivered after processing is normally good enough for the geological interpretation purpose, and fast anomaly and amplitudes checks, but <u>not</u> for QI. In the example *(a)* below, good processed CDP gathers from costumer and PSS-Geo *(b)* preconditioning applied process (Radon, trim). It is important to clean the CDP gathers as the noise related events causes bigger body detection, and bigger anomaly size *(c)*.

   Also, survey can contain several merged surveys. Merging surveys could be done by amplitude scaling and phase matching, which is less harmful for the data. Merging using amplitude scaling, phase matching and frequency contain could be harmful for the AVO and inversion process. At the preconditioning process all non-suitable processes can be detected.

a)



b)



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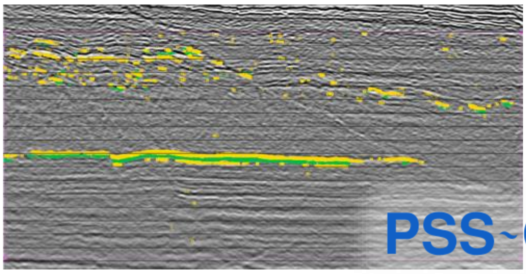
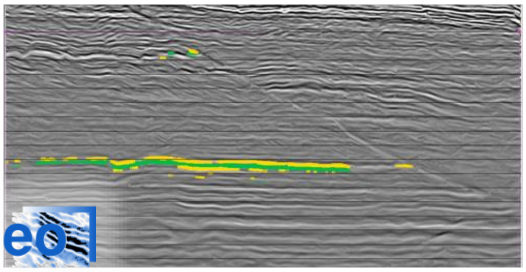
(c) AVO Anomalies of non-conditioned data

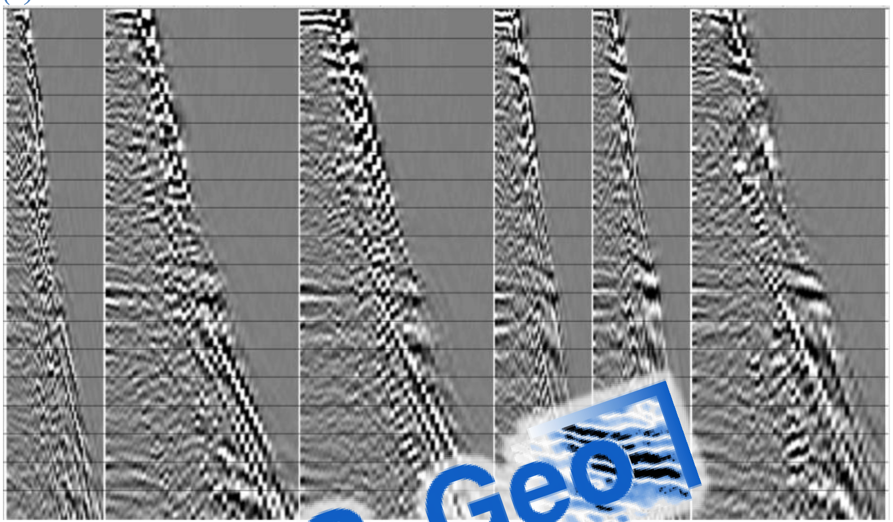


AVO anomalies of preconditioned data

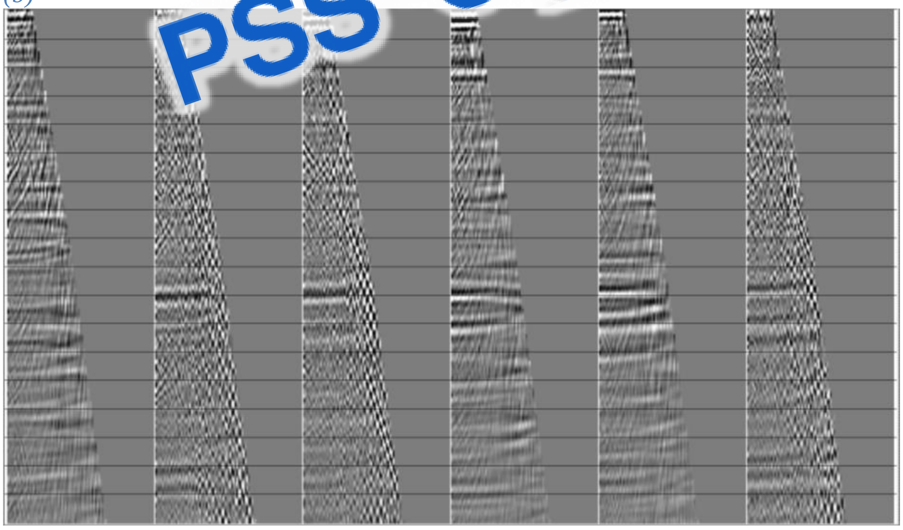


b) **Should we work with AVO stacks or gathers?** Working with AVO stacks is simpler, but AVO stacks can have anomalies that are not present in a gather. On the pictures below you can see gathers *(a)*, which PSS-Geo requested from the client that wished to run inversion based on the AVO stacks. AVO anomalies on the AVO stacks were caused by different type of noise. The picture *(b)* shows fast track preconditioning, which makes reflectors appeared in the shallow part.

(a)



(b)



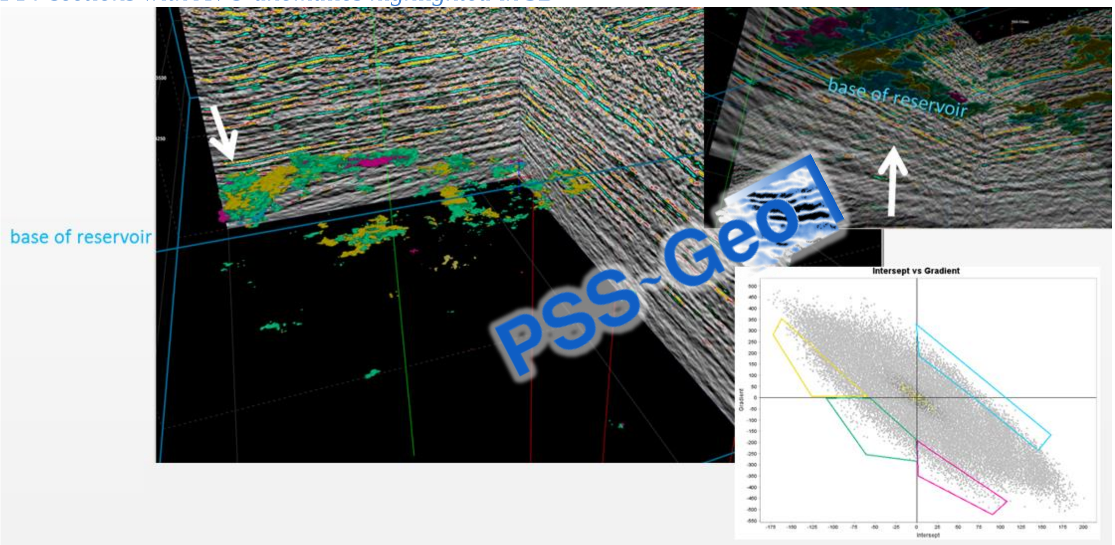
Recommendation: Preconditioning with floating angle mutes to get maximum available angle at the targets, and to maximize Density restoration.

2) **Well ties –** to check seismic phase at the target zone before creating AVO and Screening Attributes *(a)*.

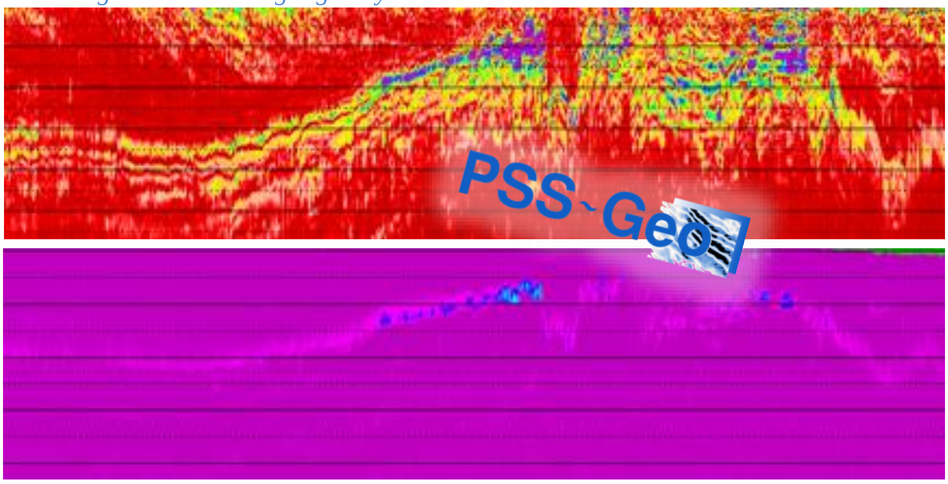
3) **AVO analysis**
   Intercept and Gradient (a), **Fluid Factor** (FFr) ($\Delta FFr = Rp(t) - g(t)Rs(t)$ with adjusted $g(t)$ according to lithology from well) *(b,c)*, **Frequency decompositions** *(b)*, etc.… - to highlight HC.
   Gradient analysis *(d)*: Variation of Reflection (Rpp) coefficients with offsets: for seismic data at the well location, and for synthetic gathers created form the well logs (including fluid substituted logs). Further, Rpp well logs signatures will be analyzed with Rpp signature from the top of the prospect. This will be done to understand which fluid will more likely give such a seismic response as the one at the studied prospect.

Examples:

a) *FFr sections with AVO anomalies highlighted in 3D*



b) *Screening attributes to highlight Hydrocarbons*



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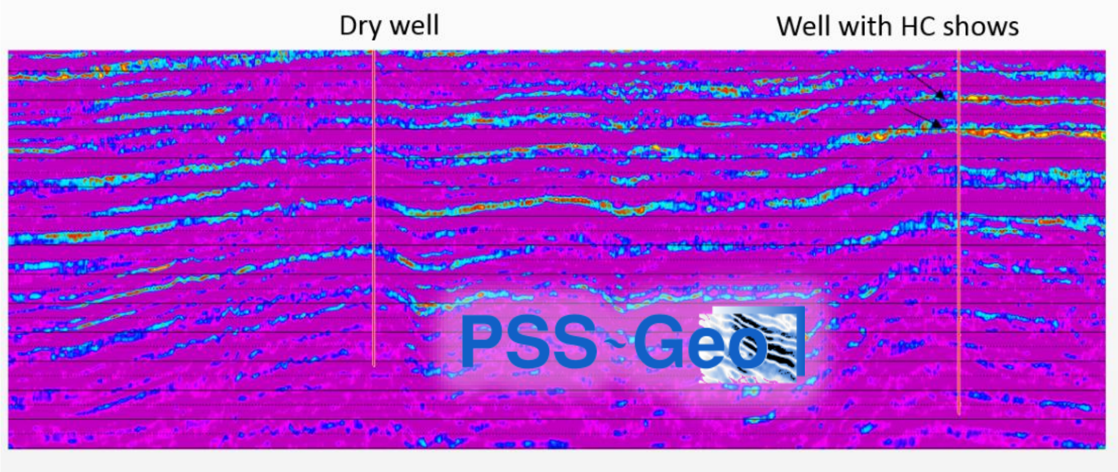
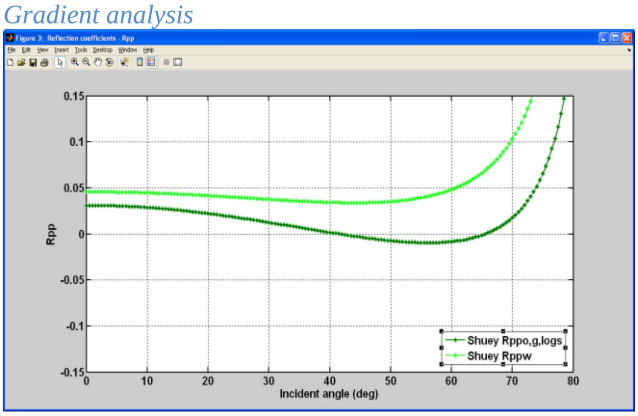
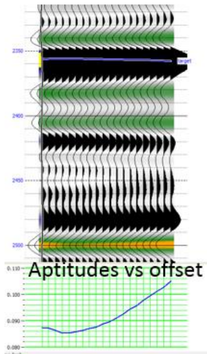
c) FFr integrated. Screening attributes to highlight Hydrocarbons



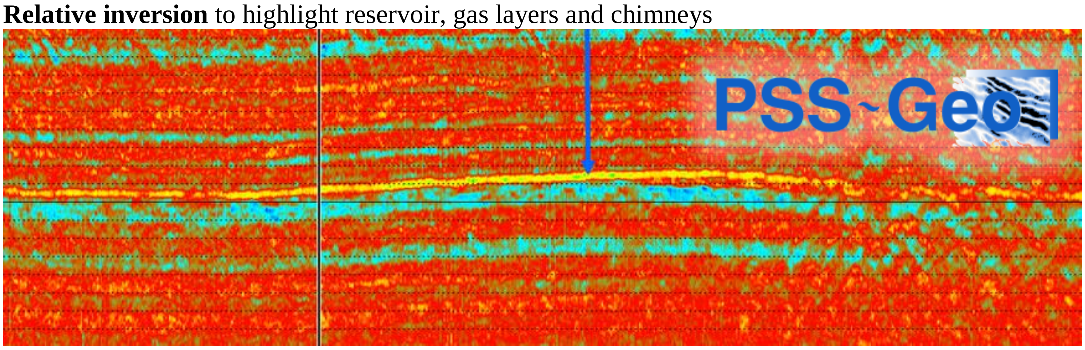
Carbonate field. Well has HC shows in two layers.

d) Gradient analysis





4) Relative inversion to highlight reservoir, gas layers and chimneys



5) Rock Physics study

Available wells are being used for Rock Physics templates/trends to define lithology, porosity and fluid (such as Poisson' ration vs Vp *(a)*, P-impedance vs Vp/Vs *(b)*, LMRho *(c)*, and any other templates if specific mineralization or other cases are detected *(d)*. P-impedance vs Porosity logs trends *(e)* at each target are analyzed for Porosity volume *(f)* recalculation.

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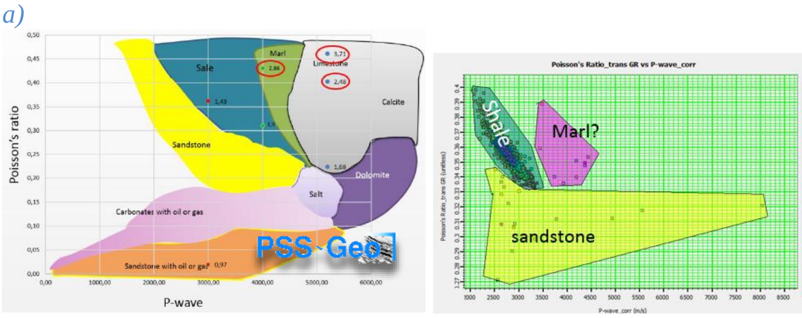
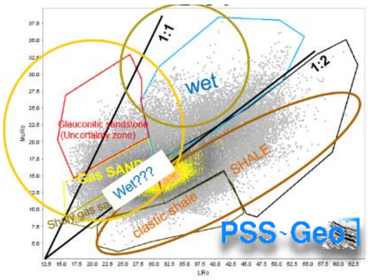
Examples:

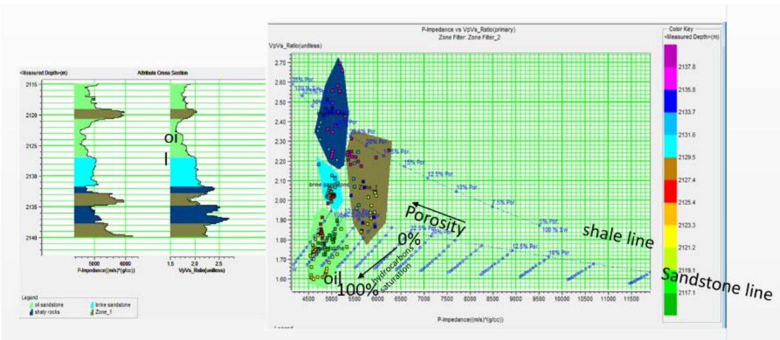
a)



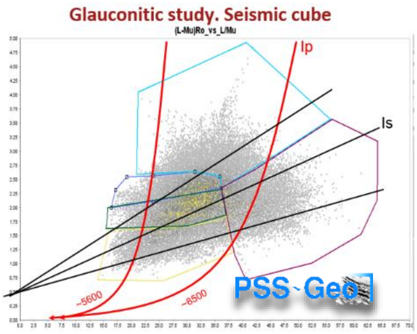
c)



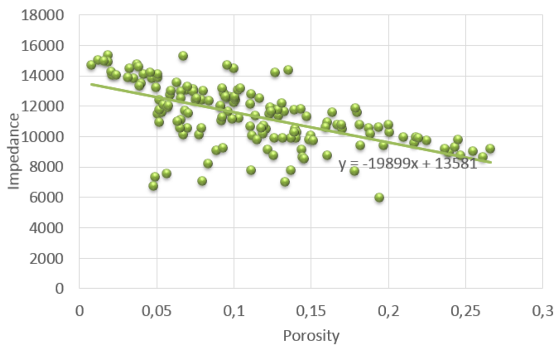
b)



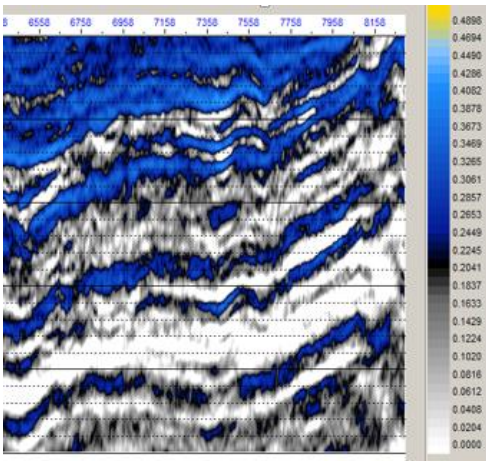
d)



e)

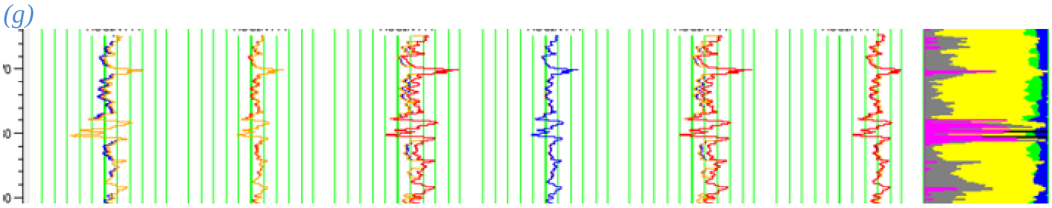


f)



Well fluid substitution (FRM) *(g)* are being performed at each formation to study fluid separation behavior for each template. *(Gassmann equation with frame as per Zhu and McMechan, 1990, Matrix VRH, density and velocity of oil as per Batzle and Wang (2001), brine and gas Batzle and Wang (1992), inverse bulk modulus averaging by as Wood's equation, PSS-Geo - code).* Synthetic gathers modeling - Hampson-Russell software.

(g)



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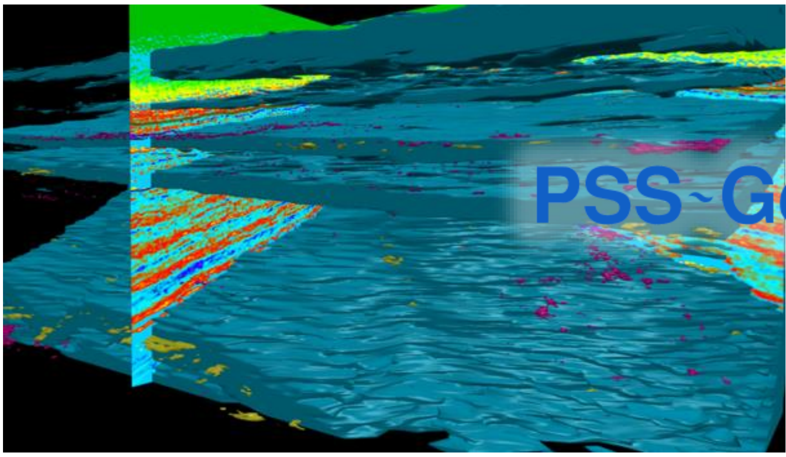
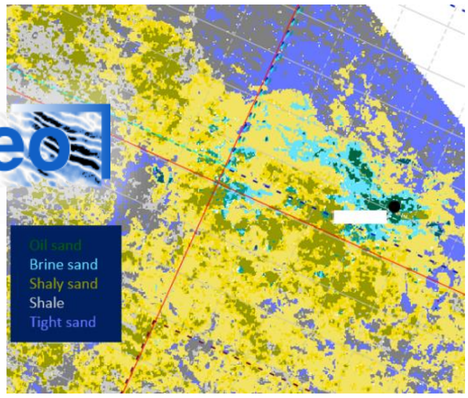
Examples:
a) 3D inverted cube: impedance seismic sections and interpreted brine sandstone layers in blue.



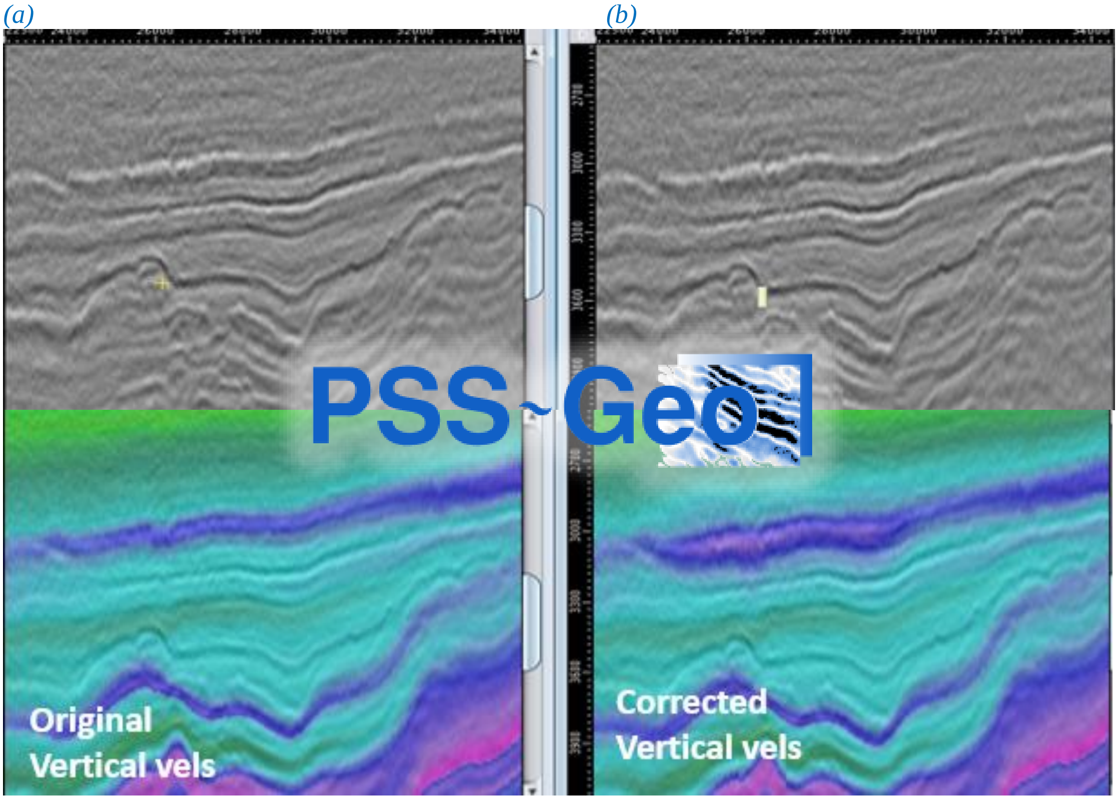
b) Map with lithology and fluid discrimination



6) **Pre-stack inversion** run on AVA preconditioned gathers with maximum possible angle. This method is based on the convolutional model. The model is an initial low frequency P-impedance model, generated from <u>well data and horizons </u>(Original vertical vels) *(a)*.

**Optional: "Hybrid Waveform Inversion". Corrected well velocity field by integration with seismic velocity: 1) horizontal velocity component reconstructed using Tomo- software, 2) calculate Anisotropy cube, 3) apply anisotropy cube to full component velocity field, 4) result is corrected velocity field (b) – more accurate for Inversion base model/depth conversion.*

(a) *(b)*



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7) PSS-Geo QI Delivery contains

- SEGY 3D **inverted volumes** of P-impedance, S-impedance, LamdaMu, LamdaRho, Vp/Vs, Synthetics, Density (with description of limitations). Porosity 3D volumes for each target. Relative P-impedance, Relative S-impedance, Relative Vp/Vs and Relative Density cubes.
- SEGY 3D **AVO and Screening attributes volumes:** minimum - Intercept, Gradient, Intercept*Gradient, FFr, FFr weighted frequencies integrated.
- SEGYs of synthetic gathers with Vp in text files.
- 3D lithology cube (geophysical interpreted cube according to defined Rock Physics templates), and AVO anomalies bodies cubes. Delivered as DUG Insight software session.
- Presentations with detailed study, video of geophysical interpreted cube, PDF report conclusion.

All pictures in the examples are taken from the 10 full Quantitative Interpretation/AVO/Preconditioning and deghosted reprocessing projects performed in PSS-Geo in the past two years: area - North Sea, Norwegian Sea, Barents Sea and Middle East.

Time

Data precondition 1-3 days for RE.
Fluid Replacement Modeling, synthetic gathers - 1 well per day.
AVA analysis (including cross plots) - 1 day per 2D/arbitrary line.
Pilot version: Reservoir Characterization – from 3 days for 2D/arbitrary lines.

QI 3D process for described flow above normally takes 1,5-3 months.

Software

ProMax 2D/3D, Fusion-3DGeo - Kirchhoff and Beam, PSDM model builder and tomography, Delphi consortium – SRME, Hampson-Russell, DUG Insight, Kingdom, Seismic Unix, Seplib and GMT, MatLab.

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